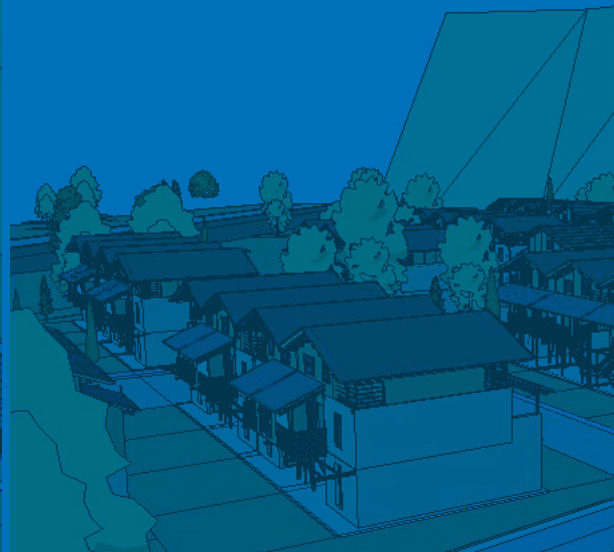
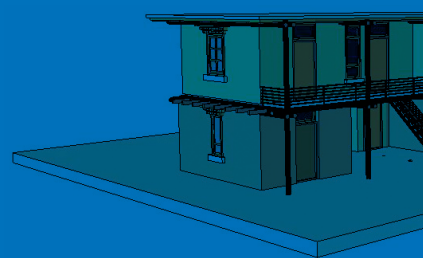
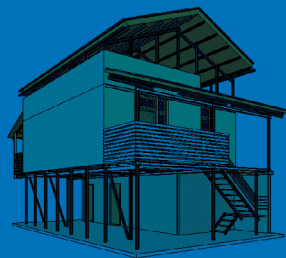
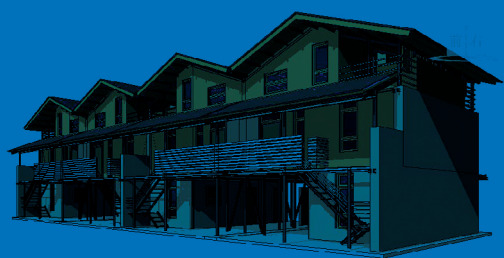




HOMES

欧 特 克 援 助 灾 后 重 建 项 目

Autodesk Acts: Ma'erkang Project in Post Disaster Reconstruction

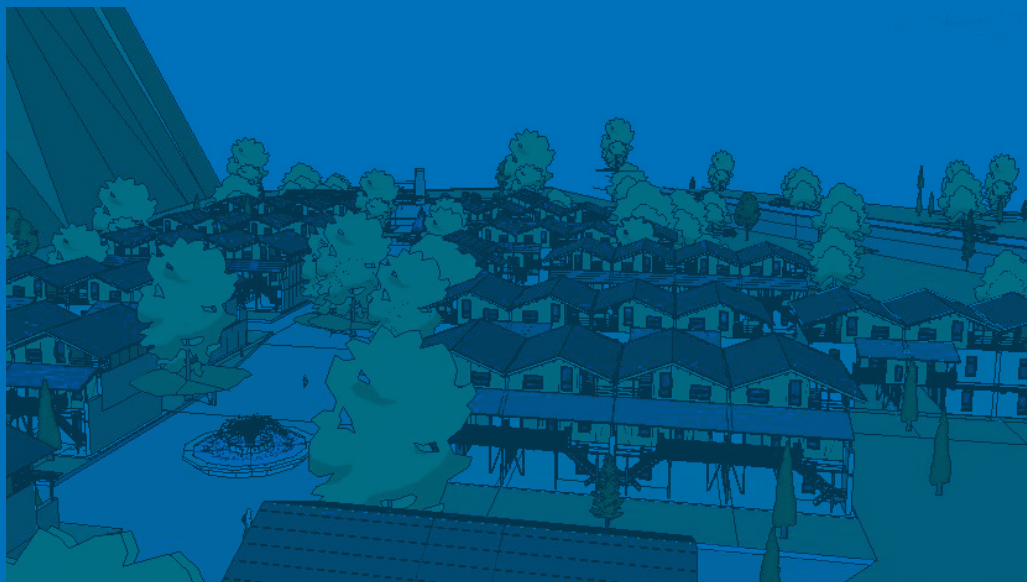
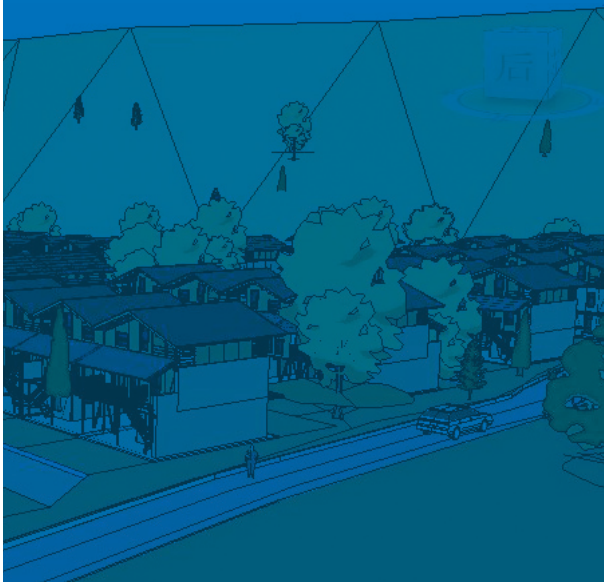
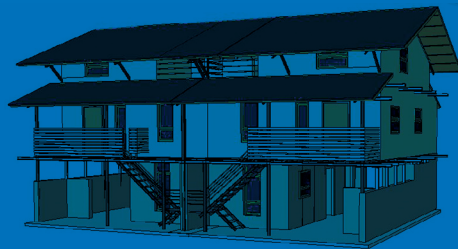
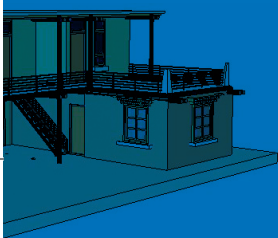


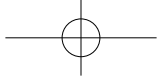


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“马尔康方案”总说明

GENERAL INTRODUCTION OF 'THE MA'ERKANG PROJECT'

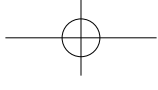
Text / 马茂林 Ma Maolin

说明：本方案说明主要基于向专家讨论会汇报时的相关资料编辑整理而成。文章中选用的图片和表格参考了相关文献资料和软件。

据初步统计，“5·12”大地震造成 13 多万平方公里的重灾区，受灾人口超过 4500 万，650 多万间房屋倒塌，2300 多万间房屋损坏，数千万人无家可归。整个中国在“众志成城”的口号下团结在一起，竭尽全力，抗震救灾。紧接其后的灾后重建工作也牵动着亿万人的心。在灾后重建工作中，由欧特克公司联合众多专业机构、建筑师、志愿者一起发起了“马尔康行动”，他们用自己的实际行动诠释了企业特殊的社会责任。

Note: This introduction is based on the materials used in the report on experts' meeting. Selected graphics in the article are quoted from related documents and softwares.

The '5·12' earthquake in Sichuan China has left 130,000m² rural area and over 45 million victims. Over 6.5 million buildings have collapsed and 23 million have been damaged. Millions of people became homeless. Carried out with the Slogan of Unity is strength, Chinese people come together to conquer the disaster. The reconstruction work after the earthquake also attracted the nation. Together with numbers of professional institutions, architects and volunteers, Autodesk initiated Ma'erkang Project in order to realize their CSR by this reconstruction program.



欧特克公司意识到灾后民居重建是继抢救生命之后要面临的又一个严峻挑战。在大家的努力下，“马尔康”爱心援建行动由此诞生。

根据谢英俊设计理念，“马尔康行动”项目组经过实地考察、方案攻关、专家讨论、技术研发等一系列重要环节后，确定了援建工作的建筑设计的技术方案。本说明就是对整个技术方案的概述。

一、面临的问题

大地震给四川、甘肃等地区造成了灾难性后果，灾后重建面临着时间紧迫、受灾人口众多、受灾地形损毁严重、灾区物资匮乏、受灾居民近乎破产等一系列难题。这就使得建筑设计方案必须适应灾后重建的特殊现状，要求“马尔康行动”项目组必须首先提交一套满足抗震要求、施工简便快捷、适宜大规模建造、便于受灾居民参与建房，且具有环保可持续性的建筑设计方案。

◆ 抗震性：

抗震要求是震后重建中建筑的首要条件。由于在地震中那些不具备抗震性的房屋很容易倒塌，破坏性极大，不仅使建筑受到破坏，而且造成大量的人员伤亡。

◆ 经济性：

大灾之后，灾区人民的财产遭受了极大的损失。他们曾经用多年积蓄建设起的家园，顷刻之间化为废墟。如何帮助无家可归的灾区人民早日搬进安全可靠的新家，房屋建造的经济性将是一个不得不考虑的问题。

◆ 大量快速建造：

汶川地震之烈，受灾地区之广，受灾人口之多，举世罕见。如何在最短时间内帮助众多的灾区居民建造房屋呢？传统的房屋建造周期比较长。况且，农村住宅不同于城市住宅，大部分都是单家独户，他们需要放置农具、饲养牲畜的地方。因此，城市住宅中大量集中建造高楼大厦的方案并不适合于受灾农村的重建。基于这种情况，受灾农村大量快速建房也是重建方案设计面临的一大难题。

◆ 多样化：

从甘肃、四川到云南，被地震摧毁的地区跨度很大，地区之间存在地理环境、建筑条件的差异性。同时，这些地区的少数民族多，传统习俗、民族特色、生活习惯等也差异很大。若是建造千篇一律的房屋，不符合地域多样性要求。由此可见，多样化设计将是重建方案设计的一个深层次要求。

Autodesk realized that post-disaster dwelling reconstruction is another serious challenge after life saving. With collective endeavor, Ma'erkang Construction-aid plan emerged.

Based on the design concept of Hsieh Ying Chun, after a series of important tasks including field study, project difficulty-cracking, expert discussion and technology research and development, Ma'erkang Project team confirmed the technology plan for the architecture design for construction aid. This introduction is a brief summary to the whole technology plan.

I. CHALLENGES LYING AHEAD

The earthquake causes problems of specific design in reconstruction, such as lack of time, large number of victims, geologically deformed land, scarce labor sources, penniless residents etc. All of these raise great challenges to designers when provide a both feasible and environmental-friendly plan which can also meet the requirements of anti-quake capability, convenience of rebuilding and easy enough for residents to understand and carry out by themselves.

◆ **Anti-quake capability:** it is fundamentally important for reconstructed houses in the disaster-hit region.

◆ **Affordability:** whether people can afford the expenditure on new house is a very practical problem because most people maybe cannot stand the economic hardship after the earthquake.

◆ **Speed and quantity:** the quake-stricken area is quite damp and cold. Therefore, a large number of houses build up rapidly is what the afflicted people need to survive winter.

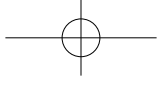
◆ **Diversity:** in the vast disaster land dwell in multi-ethnic groups with various traditions and preferences. So houses in the same pattern will certainly unattractive and that's why we innovatively would like to make our designing diversified.

◆ **Sustainability:** clarified in the Eleventh Five-year Plan, it is of great significance for generations to come.

◆ **Basic materials:** it is the key to choose suitable materials and to secure its supply for building up large amount of energy-efficient houses quickly.

◆ **Flexibility of expansion:** all reconstructed houses can only be built up step by step. Therefore it is very practical and significant to lay down the project planning in a long-term perspective so as to flexibly adapt to the future demand like reduction or expansion.

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◆ 可持续性:

我国“十一五”规划纲要中已经提出“节能减排”的政策要求，这一点也是目前任何建筑设计都需要考虑的问题。虽然目前灾区房屋建设时间紧迫，但我们还是要遵循“节能减排、可持续性”等政策要求。

◆ 基础材料:

大量快速的建造房屋，选择何种材料也是一个需要事先考虑的问题。传统房屋建造所使用的很多基础建材，国家已经限制使用。而地震中倒塌的房屋废料，是否可以重新利用？利用的价值有多大？这一点也是需要认真对待的。

◆ 弹性增建:

农民的生产、生活情况与城市居民有着很大区别，对房屋的使用需求也不一样。如果脱离了灾区农民的实际需求而进行统一的标准化设计，这样做不能满足农民生活和生产的实际需求。由此，弹性增建也是建筑师应该考虑的重要因素之一。

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如何妥善解决这些问题，就成为建筑师和重建者面临的巨大挑战。

二、方案介绍

“马尔康”重建方案的基本原型是谢英俊曾在台湾“9·21”地震之后应用的建筑设计方案，即轻钢结构生态住宅设计。

欧特克公司有方案设计、三维模型建立、结构分析、仿真模拟、实施管理、项目管理等软件，覆盖了设计、施工所有细节的完备解决方案和专业技术，这些都为进一步优化谢英俊的设计方案提供了技术支持和保障。

“马尔康”研发人员利用建筑信息模型 (BIM) 手段，在建筑选材、结构分析、可持续设计等方面进一步完善了谢英俊的建筑设计方案，使之成为一个有严密数据分析支持的、具有广泛适应性和扩展性、建造成本低、能够大量快速建造的灾后重建设计方案。

基本方案原型如下:

轻钢结构生态住宅采用薄壁型钢作为建筑龙骨，用普通螺栓进行钢结构连接，同时用大量斜撑和拉杆来确保结构稳定。地基下层填充捣碎的建筑垃圾，上层预埋地脚螺栓和 C 型钢。建筑墙体底部采用砖石材料作为基础和防水层，内墙和外墙选用竹编或者钢丝网作为围护层，墙体填充材料是当地的草、竹、土等混合材料。屋顶采用彩钢板，下面加铺稻草辅助隔热保温，天花板采用当地生长的竹子搭建，楼面采用免拆模板瓦或者木板。

Confronting with all of them above, now the architect is supposed to present a designing proposal which can provide solutions to all the challenges.

II. PROPOSAL ANALYSIS

The basic model of the Ma'erkang design is based on the 'Light Steel Structure Houses' which designed by a famous architect Hsieh Ying Chun after the earthquake in Taiwan.

Autodesk, a leading company in architecture and manufacturing design, backs this project and is trying to realize the application of BIM (Building Information Modeling). Autodesk has detailed solutions and professional technicians covering all project aspects, including design, 3D models, structural analysis, simulation, application management, project management, etc. Autodesk pays extra attention on the BIM proposal, which improves upon.

Mr.Hsieh's original design on the raw material procurement, structural analysis and sustainability, in order to make the proposal into a standardized, adaptable, expandable, economical, popular, and practical disaster relief project that is backed by rigorous data analysis support. This proposal consists of almost all of Autodesk's mainstream products, which is a perfect fit for rebuilding Sichuan.

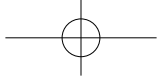
Basic proposal as follows:

Light steel structure eco-houses use light steel as the keel, which is joined by regular screws, then stabilized by massive diagonal bracings and straining beams. Bricks are used for the foundation and waterproofing, bamboo or steel wire gauze is used for the interior and exterior walls, while local grass, soil and other materials are extensively used as filling materials. The roof tiles are color steel plates with straw lining underneath to help with the insulation. The ceilings are made of local bamboo and the floors are assembled tiles or wood. The compressive sub-strata are made of wasted building materials and above that are pre-laid with bolts and C shaped steels.

Overall proposal analysis:

1. The coordination of design and structural calculation to ensure the seismic resistance of the building

The plan proposes to use light steel as the keel while cold-formed steel is used as the main structure. The light steel structure itself is great for quakeproof. In order to provide better scientific support, the team member of Ma'erkang have incorporated building design and structural calculation to strictly check each link of the designing process as well to use the structural calculation to perfect the original design in order to have better earthquake resistant construction.



整体方案解析：

1. 建筑设计与结构计算协同作业保证结构的抗震性

本方案结构体系为轻钢结构，主体结构构件均采用镀锌冷弯薄壁型钢。轻钢结构本身具有良好的抗震性。但为了在理论上给予更科学有力的支持，在设计阶段，“马尔康”研发人员使得建筑设计与结构计算协同作业，让每一个设计方案都经过严格地结构计算确认，并利用结构计算结果进一步优化原有设计方案，以确保设计方案具有更强的抗震性。

整个建筑主体结构以轻钢结构为主，梁柱系统，附加抗水平力的斜撑或剪力墙。与轻型钢 BALLON 系统相比较，采用螺栓连接，施工简便，可减少结构的节点数量。

- ◆ 轻量化—屋顶、楼板、墙体
- ◆ 轻钢框架结构加斜撑
- ◆ 草土墙，草及竹片拉结
- ◆ 水泥钢网包围护墙，以加强结构力，并防火、防锈

2. 参数化设计和开放式结构保证三维精确设计和户型变化的多样性

在基本原型的基础上，可以根据当地气候环境、民间风俗、居民生活习惯等设计出不同户型的建筑，以满足当地居民的不同需求。

例如：就户型而言，可以根据当地居民的需要，建筑的一层用来圈养牲畜，二层住人。如果用地许可，还可以设计建筑一层为客厅，并放置农具，二层住人。而在建筑的旁边设置厨房、猪圈等。此外，还可以根据农民的需求，设计不同面积的

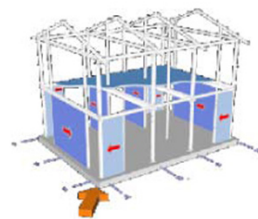
The main structure of the whole construction is light steel, beam-column system, adding diagonal bracing or shear wall against horizontal force. Compared with the Ballon-beam system of light gauge steel, it can reduce the number of structural joints. And it is linked with bolts and easy to construct.

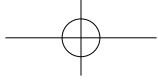
- ◆ Light gauge—Roof, floor, wall
- ◆ Light steel-Frame structure with diagonal bracing
- ◆ Grass walls—Grass and bamboo joints
- ◆ Cement Steel Net including reinforced structural capacity, fire-proof and rust-proof

2. Parameterization and open structure bring 3D precision design and housing variety

The local climate and custom can be incorporated into the original design to satisfy the needs of the people. The building materials and method can vary depend on the local farmers' customs as well.

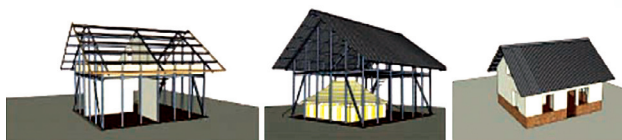
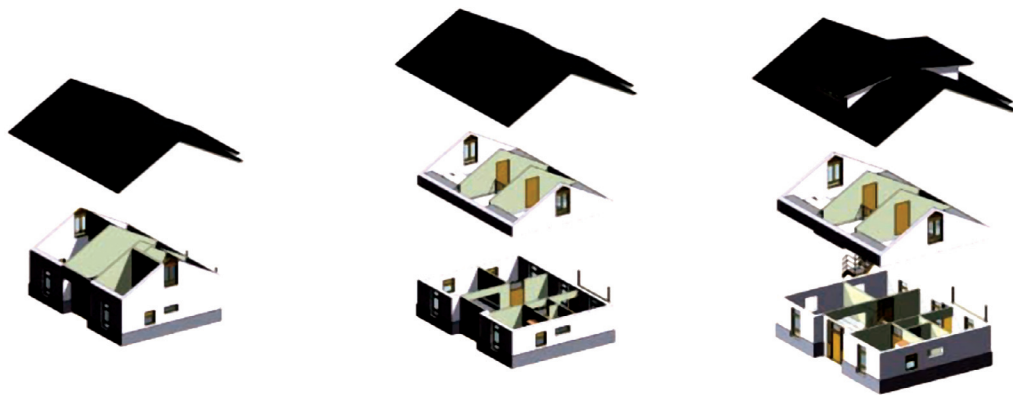
For instance, the types of the houses can be based on the practical needs of the local residence; the 1st floor could be used for caging livestock and the 2nd floor for family members. If the land space permits, for another type, the 1st floor of the house also can be designed for the living room as well as placing agriculture machinery, and the 2nd floor for family members. The kitchen and piggery, in this type, will be located beside the house. Apart from the different house types, the roof types can vary according to the climate: the dry area fits flat roof whereas the moist area fits a slopping one. Moreover, the selection of the materials for roof construction can be on the basis of the local customs, such as mud bricks or choi steels.





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The light steel structure is open and it tailors to the need of flexibility. If the farmers do not have sufficient funding, they can choose to build one or two storey building with simple fixtures. If they acquire more funds later on, they can have easily have add-ons and modifications because the structure is join together by bolts.

Parameterization is used in the design and the layout precision is guaranteed cross-section and engineering statistics. With 3D visualization design, the architect can paint an integrated and precise picture. Integrating building, structure and design, can guarantee the precision of the design while increase the efficiency of the designing process.

3. Control building cost by using local materials and statistics

In the original design, light steel is molded directly by machines in one go to avoid leftover wastes. The exterior relies heavily on local materials such as grass, soil, and bamboo and so on to minimize the cost. At the same time, the construction technology should try to be easier, so as to involve more local residence into the self-construction. Such way of construction will not only arouse the participation of the people in the quake-hit area, but also effectively mobilize the rural labor forces and cut down the cost during the construction. The quantity of work is precisely laid out based on software calculations. Each and every detail is calculated to ensure precision management and eliminate waste of materials and funds. After calculation and testing, the cost of each house is approximately RMB 500 per square meter.

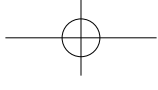
4. The integration of design, produce and construction will ensure a speedy rebuild

The light steel structure is different from masonry and wood structures, as it can be mass-produced. Combined with the integration of design produce and construction, a speedy rebuild is in order by the advanced standards and technological process.

建筑户型。就屋顶造型而言，对于气候干燥的地区，可以设计为平屋顶；而在多雨潮湿的地区，可以采用坡屋顶。坡屋顶的材料选用可以结合当地居民的习惯使用不同材料，如瓦片、彩钢板等。

基于轻钢龙骨框架结构的开放性，弹性增建的需求也能得到满足。如果农户资金不足，可以选择先盖一层或者两层的房屋，装修从简。等到以后农户资金宽裕，可以在现有的基础上进行加盖。由于所有的钢结构都是螺栓连接，所以加盖也比较简单。该方案根据机械设计基准统一的原则，把机械领域的高精度性引入到了建筑领域，设计、制造了钢结构。

在设计方法上，采用参数化、变量化设计，平立剖面 and 工程量统计双向关联，用参数化控制房间开间进深，相关图纸协调一致，保证图纸的准确性。使用建筑、结构、设备三维协同设计，同时采用三维可视化精确设计，使建筑师的思想能够完整、准确、直观地表达出来，并使房屋的内部框架结构、外部造型表现以及水电暖系统都能够按照理想效果准确表达，使得设计工作效率大大提高。



3. 就地取材和工程量精确统计有效控制建造成本

在基本原型方案中，轻钢是采用成型机直接加工成型的，一次成型无边角废料。建筑的围护部分采用当地草、土、竹等材料，从而有效降低材料成本。同时，尽量降低建造技术门槛，让当地居民可以参与自助建房，不仅调动了灾区居民的积极性，而且有效利用农村劳动力，降低建造的人力成本。利用软件精确统计工程量，详细统计每个工程的细节，实现精细生产、精细控制、精细管理，保证每一分钱都用到实处。基于501基本户型，按照当时的价格，经过理论计算，这套方案的房屋造价每平方米约500元。

4. 设计制造施工一体化保证大量快速重建

不同于砖石、砖木结构，轻钢结构体系可以大规模标准化生产。利用先进的、标准化工艺流程和质量控制，结合设计、制造、施工一体化，保证大量快速地重建。

轻钢结构生产加工工艺流程：

设计数据导入→成型→打孔→钢料截断→局部加工→整套房屋钢结构打包

在上述工艺流程的保证下，采用数控加工技术保证构件加工的精确性。现代化大规模生产，能够保证大批量、快速制造成型，然后将每一套建筑的钢结构整体包装，集中运输管理，从而实现快速施工的目标。

5. 基于建筑信息模型分析实现可持续性设计

由于该方案中大量采用了草、土、竹等绿色建材，可以重复使用，并且大大降低了碳排放量，因此满足可持续性设计要求。将Revit模型直接导入PKPM节能分析软件，可以进行节能分析。

“马尔康”研发人员利用Revit软件进行建筑设计，再将Revit模型直接导入PKPM节能分析软件进行节能计算，得出结论：采用本方案的建筑构造，可以实现建筑节能50%，并且该方案具有可扩展性，适用于夏热冬冷地区、冬季严寒地区以及不同气候条件的灾区。

以四川地区为例，将Revit模型直接导入IES软件进行室内环境质量及冷热负荷分析，得出结论：

光环境：室内自然采光好，无眩光。

日照：全年均能获得日照，夏季少，秋冬季节较多。

湿环境：墙体构造具有良好的吸湿功能，全年湿度分布稳定。

碳排放量：与同类砖混结构住宅相比，本方案建筑物的碳排放量大大降低，效果极为显著。

6. 降低技术门槛配合通俗易懂的动画模拟便于居民参与建房

(1) 简化构法、自助建房

地震后，专业的建筑施工人员比较缺乏。“马尔康”研发人

The process of Light Steel Production:

Input design data → Shaping → Punching → Cutting of steel → Partical operation → Steel structure packing

According to the production process listed above, advanced data process technology is used to ensure production precision and modern scale of production, mass production can be achieved. The steel structure for each unit can be packed, transported and managed together for the swift construction.

5. Using construction information analysis to compete sustainable design

Using the Autodesk Revit construction design, a model can be loaded directly into the PKPM software for energy saving analysis.

The result shows that using this construction structure, building energy saving rate can reach 50%. Furthermore, the solution is extensible; it can also be applied to regions with extreme summer and winter climate as well as other severe climate and weather disaster areas.

Based on Sichuan region's situation, Autodesk Revit model is also used directly with the IES software to analyze the quality of indoor air circulation as well as the load of temperature. The results are as follows:

The light environment: Indoor natural lighting is good without glare.

Daylight: Average daylight throughout the year, less during summer, more during fall and winter.

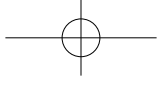
Damp environment: Wall structures have good absorbance; level of humidity is average throughout the year.

Carbon emission: Compare to similar brick concrete structure, per square meter, carbon emission can be reduced by significantly.

6. A lower-level of technological requirements and use-friendly animation makes residents' participation much easier

(1) Simplification of Construction Method, participation of reconstruction

The main structure is mostly steel jointed by bolts which can easily meet the technological requirements. Able-bodied residents can participate in the rebuilding projects after a simple training. With simple construction manuals, 4D models and 3D visual aids, farmers can easily learn the construction techniques.



DEDICATION 奉献

AUTODESK
SPECIAL



员特意将材料、构法、工具、组装等工作都做了适度简化，使结构体系标准化、构件化，钢结构只需用螺栓连接组装，施工简便。同时，提供了建造过程四维动画模拟和三维可视化节点安装模拟，可以帮助灾区居民更好地参与到重建家园的工作中。

(2) 参与建设、重获自信

让灾区居民自己参与到重建家园中，能够有效利用当地的劳动力，降低人力成本，并为他们以后房屋增建或修缮提供所需技术。灾区居民参与自助建房，对自己的劳动成果容易产生认同感，并能在房屋重建中获得自信。同时，在同心协力建房过程中，灾区居民可以相互安慰，建立新的群体关系。

三、软件技术的重要作用

“马尔康行动”所提供的概念，从设计思想的表达、设计结构的分析、设计结果的实现到构件的生产加工、现场施工等形成了一套独特的方法和流程。

“马尔康行动”设计理念的表达需要一套完整、实用的工具和合适的表达方式。在软件技术的支持下，建筑师的思想可以快速形成设计方案，还有助于建筑师、工程师、志愿者之间的沟通交流。软件技术成为援建团队的有力工具。

在“马尔康行动”实施阶段，欧特克公司的强大软件技术实现了设计制造施工一体化、数据源头一致、全部关联更新，一处变化，处处跟随。还实现了设计更改自动化，大大缩短了设计周期，提高了工作效率。

(2) Participant in reconstruction and Psychological Restoration

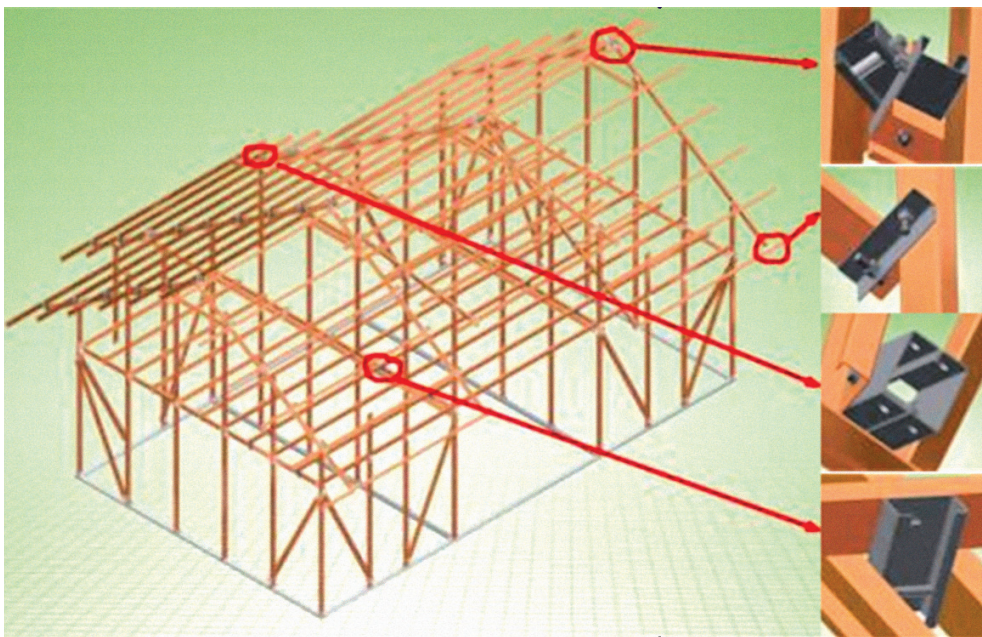
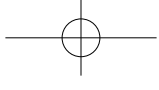
The participation of farmers can effectively alleviate the excess manpower after the disaster. This process allows them to combine their abilities with intelligence, which can help them rebuild their self-esteem. This cooperation uses labor to reduce cost; while joint efforts can strengthen the community and build new relationships. Also, by learning the new techniques, it helps the farmers to make future additions and renovations.

III. THE IMPORTANCE OF APPLYING SOFTWARE TECHNOLOGY

The design idea of the Ma'erkang Project is a very unique system in terms of design, structural analysis, processing and construction.

Ma'erkang Project needs a series of complete and applicable tools and a proper way to express the idea. With the support of software, the architect's ideas can be promptly made into proposals. This helps to facilitate communication among the architect, engineers and volunteers. Software technology is a valuable tool in the disaster rebuilding team.

In the Ma'erkang project, Autodesk's various software programs have consolidated the designing process so that all data came from a single output and this made each linkage more relevant and connected. There is also the automated updating feature, which dramatically shortened the designing cycle and increased efficiency.



屋脊衔接
Roof Connection

C型钢的侧面与侧面联结
The connection between flanks of
C-type sectional steel and roof

横梁与后院屋顶联结
The connection between stringer
and Roof of the back yard

二楼地板双梁夹柱
Dual-beam pillar
between double floors

作为一个在工业、建筑等设计领域领先的软件公司，欧特克公司拥有全世界最全面的设计软件产品，主要包括：

◆ **Autodesk AutoCAD**：二维工程设计领域中应用最广泛的专业软件。


◆ **Autodesk Revit**：通过三维参数化、变量化设计，实现户型在结构计算要求范围内自由调整，实现三维实体精确设计、户型变化多样性、工程量的精确统计。

◆ **Autodesk Inventor**：在自动打孔的同时自动添加标准紧固件，输出成标准格式。结构件打孔孔位的简单易懂的表达，使得方案从设计到轻钢加工实现一体化。基于精确设计，大到钢材，小到一个垫片都能实现完整、准确的统计。可视化节点安装模拟，让应用者可以容易地看懂安装过程。

◆ **Autodesk Robobat**：直接导入模型数据进行精确地结构分析。

◆ **Autodesk Navisworks**：专业建筑施工动画制作，实现四维建造模拟和三维可视化。

◆ **Autodesk 3ds Max and Autodesk Maya**：领先的渲染和制作软件，让专业设计变得通俗易懂，让更多的人能理解专业设计，让更多人参与房屋建造。

由于这些软件产品具有从方案设计、数据分析、模型建立到施工管理、预先模拟的全套功能，从而在材料选择、应力分析、可持续设计等方面进一步完善了谢英俊原先的建筑设计方案，进而发挥软件在重建工作中的作用。 

As the leading corporation in the industrial and design industry, Autodesk has the world's most advanced software products, including:

◆ **Autodesk AutoCAD**: 2D industrial design's most popular software

◆ **Autodesk Revit**: Using 3D-CAD application, a more precise, adjustable and diverse design can be delivered when it comes to unit structure calculation.

◆ **Autodesk Inventor**: During automated hole-punching process, standardized components will be added for a more standardized output. The clear illustration for hole-punching position for the components allows easy understanding of the design, which gives a smooth delivery from the designing process to the processing of the light steel. Based on the precision design, a precise calculation can be used, be it large pieces of steel or a small part. The visualized construction model can allow the assemblers to easily understand the entire process.

◆ **Autodesk Robobat**: Directly uses the model data for more precise structural analysis.

◆ **Autodesk Navisworks**: Professional construction animation production for 4D models and 3D visualization.

◆ **Autodesk 3ds Max and Autodesk Maya**: Leading color application and production software can transform professional designs into laymen terms so that more people can understand the design and participate in the rebuilding process.

The above software have many functions ranging from project design, data analysis, model building to construction management and model forecast. The use of software in the rebuilding process further perfects Mr. Hsieh Ying Chun's proposal in many areas including material procurement, stress analysis, sustainability and so on. 